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OCCURRENCE AND RELATIONSHIPS OF THE RÍO CHICO FAUNA OF PATAGONIA[1]

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In the last paper of this series the more important available fossils from the Río Chico Formation were described, figured, and, as far as new and definable, named. In the present paper the various fossil localities are enumerated, sufficient stratigraphic data given to specify the geologic provenience of the fossils as exactly as possible, the mammals found at each horizon and locality listed, and the general relationships and probable age of the fauna summarized. The field observations in this paper were made in 1930–31 and 1933–34 by the Scarritt Expedition. Acknowledgements of assistance received were made in the last paper.

CAÑADÓN HONDO

Cañadón Hondo is a valley, or more descriptively a nearly circular erosional basin, with a dry, winding watercourse which empties into the Río Chico del Chubut immediately above Paso Niemann. The stratigraphy here is very complex and extraordinary and its study is complicated by much pre-Patagonian (but post-Casamayor or later) faulting and local folding, by much slumping of the beds in the bottom of the basin, and the peculiar lithological facies which include several types of rocks not seen by us in these formations at any other locality. The very irregular valley or basin bottom has exposures in almost all parts, but a complete section cannot be traced because of rapid lateral lithologic changes, faulting and slumping, and frequent local lack of exposure at crucial points in the series. Short of a detailed topographic and geologic survey, beyond the possibilities of our own work, a definitive arrangement of this complex series is not possible, in fact absolute certainty on many points seems unobtainable by any method.

The broad sequence which seems probable from our own observations is as follows, beginning with the oldest beds:

1. Pale clays and massive, fine to coarse, cross-bedded sands, usually white or

[1] Publications of the Scarritt Expeditions, No. 25.

gray but often greenish or pink to red. Although physically similar and not certainly separable at present, these include two parts possibly distinct in age:

a. A lower series without fossils, in which appears a "banco negro"—band of black or dark brown clays.

b. An upper series of pale clays and sands in which are intercalated coarse sandstone lenses with mammals. Whole thickness not measurable but at least 100 feet.

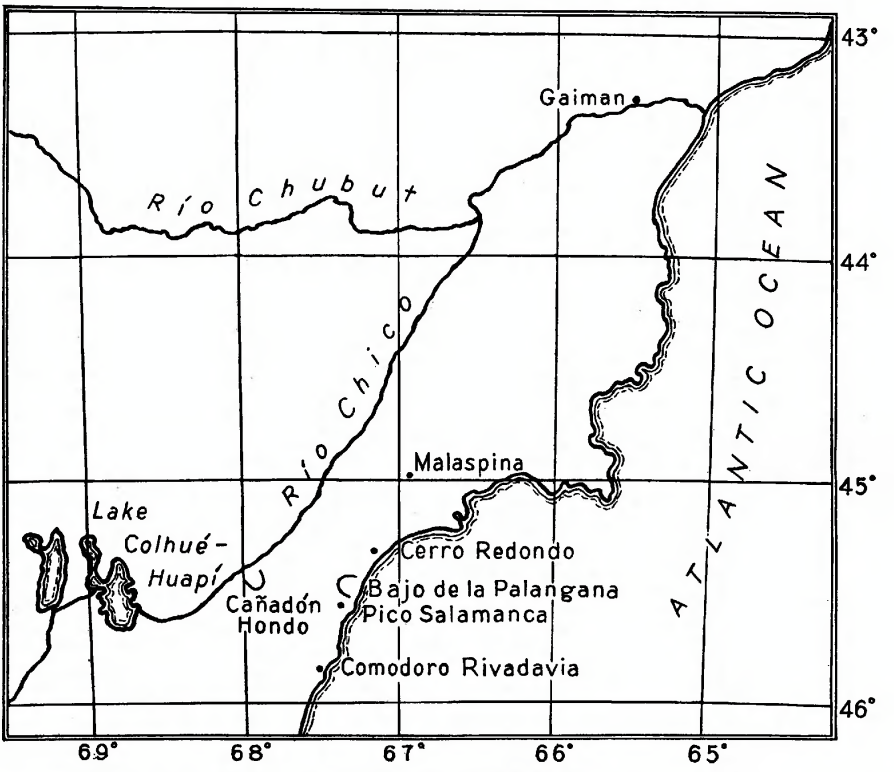

Fig. 1. Sketch map of part of central Patagonia, showing the localities mentioned in the text.

2. Green clay (bentonite) sometimes with bright red spots, scattered pebbles, associated with green and, more rarely, white sands. Whole thickness not measurable, but at least 125 feet. No fossils found.

3. Pale green, occasionally highly silicified (opalized) tuffs of "argiles fissilaires" type (see McCartney 1934, pp. 4–5; rocks 74 and 75 are from this series) alternating with bright green clay (bentonite). In the lower part of this series are several thin but widespread beds of pure white rock, specific gravity less than that of water,[1]

[1] This peculiar rock has been studied by G. C. McCartney and an X-ray analysis made by Professor P. F. Kerr. The latter notes that the X-ray pattern is of a crystalline mineral apparently not a clay mineral. McCartney notes angular glass fragments and a few zircon crystals and fragments of quartz and feldspar, but the preponderant mineral is not identified.

and also very thin-bedded fine sands and laminated shales. There are also local and minor intercalations, probably in this series, of purer or less altered tuffs or ash rocks, sometimes of the predominate green color but more rarely pink, yellowish, or white. Whole thickness not measurable, but at least 215 feet (measured in one continuous section). Fish and plant remains (see Berry 1932; field number 421 is from here) occur in the laminated beds, and mammals in the green opalized tuffs and bentonite. A small isolated exposure of pure green bentonite, probably in the upper part of this series, yielded numerous bird and rarer crocodile and turtle remains. Some isolated mammal fragment discoveries may also belong here.

4. More or less massive, white, pink, or rarely yellowish tuffs with some bentonite. The uppermost part has local lava intercalations, and this upper section may be more complex and of different age than the bulk of these pale tuffs. Whole thickness not measurable but at least 290 feet. Mammals found at various isolated localities, probably all in the middle or lower part of these tuffs.

5. The Patagonian marine, with a well-defined unconformity at its base.

The mammalian remains from groups 3 and 4 of this very generalized section are all of Casamayor age, and there is no doubt that this is all Casamayor (with the possible but unproved exception of a small part of the top of 4), in spite of the remarkable variation in lithology. The sands, 1b, which are the important point for present purposes, unquestionably underlie the proved Casamayor, and probably are considerably below it. Where the mammals occur, there are at least 30 feet of similar sands and clays above them. Beyond this the section cannot be traced continuously, but there are at least 150 feet, and probably considerably more, of sediments between these mammals and the lowest beds surely of Casamayor age. The presence of an unconformity is entirely possible, but cannot be definitely proved.[1]

The matrix in which these ancient mammals occur consists (macroscopic examination) of grains of clear quartz, generally from 0.5 to 3.0 mm. in maximum diameter, with subordinate pink and white undecomposed feldspar grains, pellets and interstitial filling of yellowish or greenish bentonite, and minor amounts of subordinate minerals. There are some streaks of a black mineral probably magnetite. Most of it is technically medium coarse sandstone, varying from fine sandstone to granule conglomerate. The quartz grains are poorly rounded,

[1] Piatnitzky (1931, pp. 10–11) has briefly mentioned the geology of Cañadón Hondo. Although less detailed than the still summary account given here, Piatnitzky's views are in general compatible with mine. He states that the sandstone with mammals is 20 meters below the limy shales with fishes. I suggest that this figure cannot be exact, due to the inclination of the beds, the presence of numerous faults, lateral variation, and the absence of continuous exposures between the two sites, and that it is probably considerably too small. It should also be noted that petrographic study shows that he is mistaken regarding the nature of the bed in which the bird bones occur. It is not a somewhat silicified compact tuff but a very pure bentonite, like that occurring in almost all Casamayor exposures except for its green color. The hard beds which he mentions between the fish bed and the "*Strophocheilus* tuff" (the upper tuffs, 4 of my summary section) are, on the other hand, silicified tuffs and are almost identical with the "argiles fissilaires" except in color. They contain mammals of Casamayor age.

and many are fully angular. The feldspar, although much less abundant than quartz, seems to be undecomposed and the clayey material seems to be mostly bentonite and not kaolin, hence not a product of feldspar decomposition. Fresh surfaces are gray, sometimes with a greenish or yellowish tinge, and weathered surfaces tend to acquire a pale or decided orange tone. The particular lens from which most of our specimens came is strongly indurated, but does not effervesce with

Fig. 2. Exposures of the Río Chico Formation in Cañadón Hondo.
The greater part of the *Kibenikhoria* fauna was gathered from the sandstone lens in the right foreground and others of the same character in the immediate vicinity.

diluted hydrochloric acid. Adjacent beds, otherwise similar, are not indurated. These details are given because, with much variation, they characterize a type of rock common enough in itself but which does not appear ever to occur in the true Casamayor (or any other later formation of this region, at least until the Patagonian or still later strata which I have not examined in such detail).

The fossils are always isolated and most of them have been weathered, rolled, or broken before burial. The teeth, however, are usually

implanted in jaw fragments, and in a large proportion (nearly one half) of the specimens with teeth, more than one tooth is present. Complete dentitions were not found in any case, the nearest approach being a maxilla with six teeth.

This site was found by Ing. Alejandro Piatnitzky, who has already announced the discovery (1931, p. 11). I have also mentioned the occurrence previously (1932, pp. 6–8). The Scarritt Expedition worked here in March, 1931, and made the collection listed below. Feruglio also made a somewhat smaller collection, which has also been studied, but Piatnitzky's specimens are not included here. The mammals identified are as follows (descriptions in the previous paper):

MARSUPIALIA
- Borhyaenidae
  - *Patene* sp.
- Polydolopidae
  - ?*Polydolops kamektsen* Simpson

INC. SED.
- *Gashternia ctalehor* Simpson

CONDYLARTHRA
- Didolodontidae
  - *Ernestokokenia yirunhor* Simpson

?LITOPTERNA
- Gen. et sp. indet.

NOTOUNGULATA
- NOTIOPROGONIA
  - Henricosborniidae
    - *Henricosbornia waitehor* Simpson
    - ?*Peripantostylops orehor* Simpson
  - ?Notostylopidae
    - Gen. et sp. indet.
  - ?Notioprogonia inc. sed.
    - *Seudenius cteronc* Simpson
- ENTELONYCHIA
  - Isotemnidae
    - ?*Isotemnus ctalego* Simpson
    - Gen. et spp. indet.
- TYPOTHERIA
  - Notopithecidae
    - ?*Transpithecus* sp.
    - Gen. et sp. indet.
  - Acoelodidae
    - *Kibenikhoria get* Simpson

?TRIGONOSTYLOPOIDEA
- *Shecenia ctirneru* Simpson

The peculiar conditions of deposition make it unlikely that any identifiable large mammals will be found, but there were some large species, for a toothless jaw fragment, wholly unidentifiable, indicates an animal as large as *Thomashuxleya* or *Carodnia*. This does not invalidate comparisons, however, for the microfauna of the Casamayor is better known, or at least represented by many more specimens, than the macrofauna.

None of the identified species, and few of the genera, occur in the Casamayor. Even where the name of a Casamayor genus has been used for one of these animals, in most cases this is because the material is inadequate to define a new genus and not because it surely or even probably belongs to the Casamayor genus. In the case of *Henricosbornia* and, less clearly, of *Ernestokokenia* it does seem probable that the Casamayor genus occurs here, but in the other cases the Río Chico species will probably prove to belong to new genera when better known. That some Casamayor genera are common to the two faunas remains probable, but that this is true of any species seems very improbable.

The fauna is essentially primitive. The elements here present are, on the whole, the most primitive of the Casamayor fauna, and where closer comparison is possible the Río Chico species seem to be more primitive. *Ernestokokenia yirunhor* is a primitive form even within its primitive group. *Shecenia*, if really related to *Trigonostylops*, seems to be more primitive, at least in the somewhat smaller tusks and much larger tooth in the diastema. The henricosborniids are the most primitive of South American notoungulates. If *Seudenius* is a henricosborniid, it is very primitive in structure despite its larger size, and if it is either a notostylopid or an isotemnid it is very primitive in its group both in size and in structure. *?Isotemnus ctalego* is one of the most primitive known isotemnids. *Kibenikhoria* seems to be less advanced than its allies *Ultrapithecus* and *Oldfieldthomasia*.

CERRO REDONDO

The hill to which we applied the descriptive field name Cerro Redondo is about one kilometer in diameter, near its base, and its apex is about five and one-half kilometers nearly due west of Puerto Visser.[1] Although fossils are few, the locality is one of outstanding stratigraphic importance, and I give the pertinent part of the section in full, starting at the base of the peak and ascending its southwest side.

[1] The official name of Puerto Visser seems to be Puerto Figueroa Alcorta, but I have never heard the latter name used. Our "Cerro Redondo" apparently does not have an official name. It appears on a sketch map by Tapia (1929, opposite page 502) as "Cerro Visser," and in an illustration (Pl. xx) as "Cerro de P[uerto] Visser."

a. Yellow-green to dark blue-green glauconitic sandstone with *Gryphaea*.....Not measurable here.
b. Thin-bedded fine sands and shales with conchoidal fracture, shell casts and plant impressions..... 35 feet.
c. Green sandstone with fossil wood (the "Banco Verde" of local stratigraphers)..... 20 feet.
d. Chiefly black shale ("Banco Negro" or "Banco Negro Inferior")..... 15 feet.
e. Yellowish, greenish brown, to chocolate-colored clays with thin streaks of red..... 30 feet.
f. Gray to red clays with lenses of white, greenish, or red, coarse, cross-bedded sandstone..... 60 feet.
g. Cross-bedded white sandstone with red streaks..... 15 feet.
h. Clay and sandstone, similar to "f" but with rather less red and more gray sandstone. Mammals at base..... 75 feet.
i. Fairly persistent white sandstone..... 15+ feet.
j. Chiefly pale clays, some lenses of white sandstone..... 100 feet.
k. Cross-bedded sandstone and fine conglomerate. Mostly white or yellowish, but upper part a characteristic pale violet as seen from a distance..... 35+ feet.
l. Chiefly pale clay..... 55 feet.
m. Lens of hard cross-bedded gray sandstone, weathering reddish. Mammals..... 0–5 feet.
n. Soft gray to greenish sandstone..... 15 feet.
—Top of cerro, elevation about 725 feet above sea level—

Practically all of the "clays" of this field section, including those of the Salamanca, and the "Banco Negro," are bentonites. On the basis of this section and of our rock specimens from it, McCartney (1933, p. 15) has shown not only that beds "a" and "c" (the "Banco Verde") are glauconitic (as has long been known), but also that glauconite is an important constituent of parts of bed "e." While it is possible that the glauconite is here secondary, it is suggested that marine and semi-marine conditions may have persisted or recurred until after the deposition of this stratum. If so, the Salamanca (in the broadest sense) perhaps should not be taken as ending beneath the "Banco Negro Inferior" but some 45 feet higher, in this section. There are many local erosional unconformities in the section, but none can be selected as of sure regional significance.

The lowest mammals found are from the base of "h," 120 to 125 feet (36.5 to 38 meters) above the base, or 105 to 110 feet (32 to 33.5 meters) above the top, of the "Banco Negro Inferior." This is 8 to 9.5 meters nearer the base and 4.5 to 6 meters nearer the top of the "Banco Negro Inferior" than the lowest mammals found elsewhere (see Bajo de la Palangana, below) and to these few teeth belongs

the honor of being the oldest mammalian remains yet found in South America. They were collected by C. S. Williams and O. García Fanjul.

Bed "m," which also contains mammals, is about 280 feet (85 to 86 meters) above the lowest mammals found and about 385 feet (117 to 118 meters) above the top of the "Banco Negro Inferior." It corre-

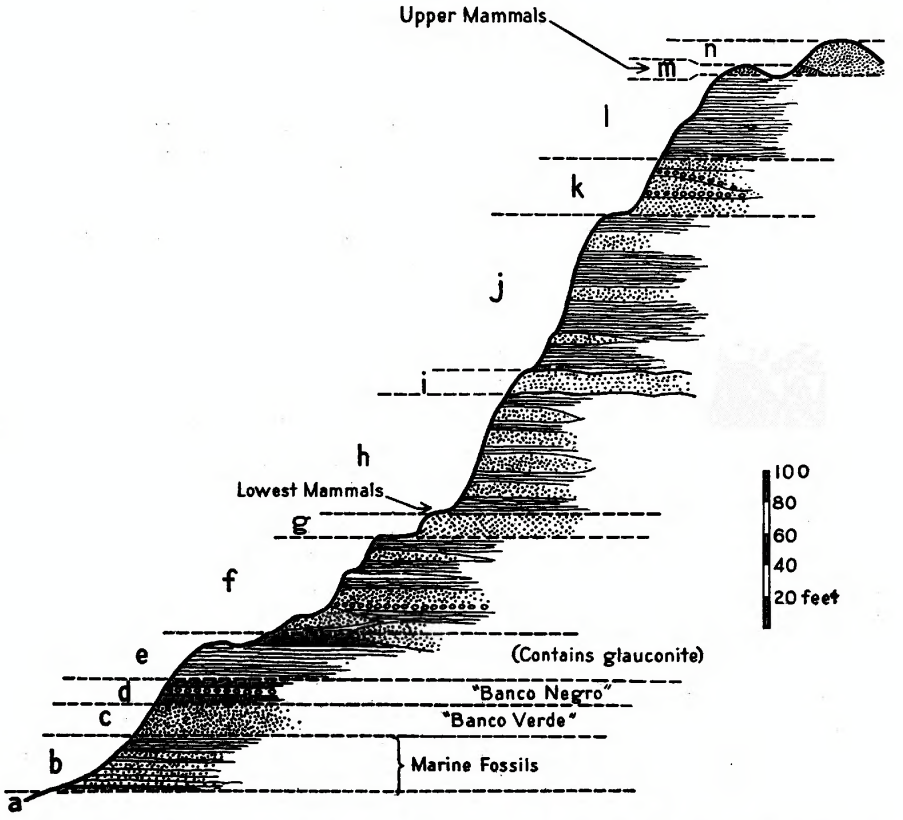

Fig. 3. Diagrammatic section of Cerro Redondo near Puerto Visser. For explanation of reference letters see text.

sponds, within a few feet, to the richest upper sandstone of the Bajo de la Palangana (see below). This horizon is at or immediately below the base of the Casamayor tuffs, although these have been eroded at this point and do not appear in the cerro itself. The fossils found are as follows:

1. Base of bed "h" of above profile.
   Crocodilidae, indet. (Scutes, skeletal fragments, isolated teeth.)

?Borhyaenidae, indet. (Canine fragment.)
Seumadia yapa Simpson.
Wainka tshotshe Simpson.
Wainka tshotshe? (Lower molar perhaps of this form.)

2. Bed "m" of above profile.
Chelonia indet. (Carpace fragment.)
Dasypodidae indet. (Two scutes, suggestive of *Utaetus*.)
Isotemnidae indet. (A lower molar representing a small and primitive member of this family.)
?Notopithecidae indet. (Lower jaw fragment with one broken tooth, suggestive of this family but not exactly matched in any other specimen known to me.)

Aside from the fact that both faunules are clearly Tertiary and that they are both more suggestive of the Casamayor than of any later fauna, but that neither compares exactly with any definitely Casamayor faunule, the fossils do not cast much light on correlation. (1) has only two exactly identifiable mammals, both distinctly different from any known from any other horizon and locality. (2) has no identifiable forms, but suggests a primitive Casamayor-like fauna. Both are consistent with the stratigraphic evidence that (2) is slightly and (1) definitely earlier than the true Casamayor. On clear stratigraphic evidence, (2) corresponds to the fairly extensive fauna from the highest sandstones of the Palangana section, listed below, while (1) is somewhat, but perhaps not significantly, earlier than the horizon of *Carodnia* in the Palangana basin.

BAJO DE LA PALANGANA

The Bajo de la Palangana ("Washbowl Basin") is an erosional basin near the coast north of Pico Salamanca, separated from the Solano Basin by that peak and the spur which connects it with the Pampa de Castillo. It is in this region that von Huene found the possible dinosaur claw (1929, pp. 13–14) and I have previously mentioned the locality and given a photograph of a "Pehuenche" (= Río Chico) exposure (1932, pp. 5–6, and Fig. 3). In 1931 we visited this locality, took several sections of the middle and upper beds exposed, and collected a small number of mammals. In 1934 I again visited the basin with Ing. José Brandmayr, who kindly indicated to me the exact horizons of the specimens found by him and by Dr. Egidio Feruglio.

In this general area the Salamanca Formation is exposed (along and near the coast, especially at Punta Peligro), capped by the "Banco Negro Inferior" of local workers, here about 8 meters in thickness. Then follows a series of sands and clays, partly or wholly terrestrial,

115 to 118 meters thick. (These figures were supplied by Ing. Brandmayr.) Above these are normal Tertiary tuffs, 285 feet thick according to our measurements at Pico Chico, three kilometers north of Pico Salamanca, and representing the Casamayor only. The Patagonian overlies the Casamayor with marked erosional but not angular unconformity.

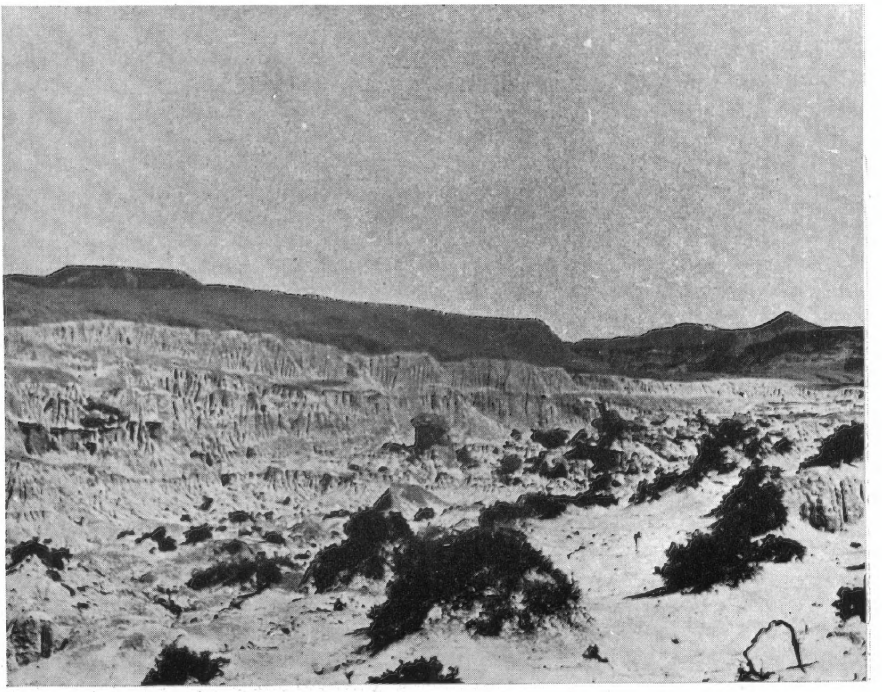

Fig. 4. Red beds of the lower Río Chico Formation in the Bajo de la Palangana, near the type locality of *Carodnia feruglioi*.

The series intercalated between the Salamanca and the Casamayor, is divisible lithologically into three members. The lower member is 24 meters thick and has a thin, dark, somewhat irregular bed, identified by Feruglio and Brandmayr as the "Banco Negro Superior," at its upper limit. No fossils have been surely recorded in this member and its age is not clear. The middle member, up to 55 meters in thickness, consists predominately of thick cross-bedded red or red and white sandstones, with intercalated clay lenses. The upper member is 30 to 35 meters thick where measured by us, and differs from the middle

member in the more commonly white or gray, rarely pink, color of the sandstone, and the predominance of yellowish, greenish, or reddish clay, being more a clay series with sandstone lenses than a primarily sandstone series like the middle member. The fossil evidence is inadequate to determine whether these lithologic members are also temporal units, but this is a distinct possibility. The middle and upper

Fig. 5. The northern part of the Bajo de la Palangana.

In the foreground the upper Río Chico capped (near the level of the low bench visible across the middle of the picture) by sands with the *Ernestokokenia chaishoer* fauna. The cliffs above this, in the background, are formed by the Casamayor, unconformably overlain by the Patagonian marine beds, which also form the highest and most distant slopes visible.

members at least are of fluviatile nature and have many local erosional unconformities, the regional value of any one of which can only be surely determined on paleontological data.

In the middle member, three fossil discoveries are known to me. Brandmayr found mammal remains 14 meters above the "Banco Negro Superior," 38 meters above the more persistent and surely identifiable "Banco Negro Inferior" and 77 to 80 meters below the base of the Casamayor tuffs. This material is now in the Museo de La

Plata.[1] Feruglio found a small lot of mammal remains, at least two individuals, *in situ* in a bed of red sandstone approximately 19 meters above the "Banco Negro Superior" and another small lot, of one or two individuals, in the same bed, in part *in situ* and in part weathered out, 20 meters above the "Banco Negro Superior." These specimens are described in the previous paper All three discoveries are within a span of six meters stratigraphically, and represent essentially contemporaneous animals.

In the upper member, bone fragments may be found in most of the sandstone beds by long search. Identifiable specimens, however, have so far been found in this basin only in the upper part of this member, and particularly in a persistent hard sandstone, about six meters below the Casamayor tuff (from which it is separated by clays or bentonites which could belong to either series) and 65 to 74 meters above the mammals referred to in the preceding paragraph. This sandstone contains abundant bone fragments, but well preserved teeth are relatively rare and almost always isolated. We have a few specimens from in or near this horizon, but the list given below is almost exclusively based on a large collection made by Feruglio.

1. 19 to 20 meters above the "Banco Negro Superior," in fine red sandstone:
   Carodnia feruglioi Simpson
   Ctalecarodnia cabrerai Simpson.

2. 85 to 88 meters above the "Banco Negro Superior" and about six meters below the Casamayor tuffs, in coarse gray to pink sandstone.

MARSUPIALIA
  Polydolopidae
    Polydolops winecage Simpson.
CONDYLARTHRA
  Didolodontidae
    Ernestokokenia chaishoer Simpson.
    Ernestokokenia ?yirunhor Simpson.
LITOPTERNA
  ?Proterotheriidae
    Victorlemoinea sp.
    Ricardolydekkeria sp.
    Josepholeidya sp.
NOTOUNGULATA
  NOTIOPROGONIA
    Henricosborniidae
      Henricosbornia ?lophodonta Ameghino.
      Henricosbornia sp.
      ?Polystylops sp.

[1] See note at end of this paper.

?Postpithecus sp.
Gen. et spp. indet.
?Notostylopidae
?Notostylops sp.
ENTELONYCHIA
Isotemnidae
Isotemnus cf. *primitivus* Ameghino
Isotemnus sp.
TYPOTHERIA
Notopithecidae
?Notopithecus sp.
Gen. et spp. indet.
TRIGONOSTYLOPOIDEA
Trigonostylopidae
Trigonostylops sp.

Of (1) nothing can be said except that the animals are from very old strata and that nothing closely similar to them has ever been found elsewhere. (2) is clearly similar to but not the same as the older Casamayor faunules. Most of its genera seem to be the same as Casamayor genera, although in the case of queried names it is probable that a generic distinction exists, although not definable from the isolated and often imperfect teeth available. The species are probably in large part new, although only two are exactly identifiable as such. In other cases (e.g., *Victorlemoinea*, *Josepholeidya*, *?Postpithecus*) the species are probably new but cannot be defined because surely homologous Casamayor teeth are not available, and in still others (e.g., *Ricardolydekkeria*, Henricosborniidae gen. et sp. indet., *?Notopithecus* sp.) the species are also probably new but the material inadequate for definition. *Ernestokokenia yirunhor* is a Cañadón Hondo, Río Chico Formation, species probably but not surely present here also and *Henricosbornia lophodonta* is a Casamayor (probably only Lower Casamayor) species probably present here. The fauna thus has the aspect of being close to the Casamayor but slightly earlier.

PICO SALAMANCA

On the south side of Pico Salamanca much of the Río Chico Formation is exposed, but neither top nor bottom contact was found by us. Starting at the shore there is about 30 meters of red (and in lesser part white and green) cross-bedded sandstone, apparently corresponding to the "middle member" of the Palangana section, and above this 20 meters or more of white to gray clay with lenses of white to pink sandstone. The upper part is obscured by slumped blocks of Patagonian. In the

upper sandstone lenses of this upper pale clay series, and probably near the level of the most fossiliferous upper sandstone of the Bajo de la Palangana, mammals occur. We found a dasypod scute and an upper incisor of *Notostylops* or some related genus, in place at this level. On the bench at the base of the cliff we found a lower premolar of *Notostylops* or a closely related genus and an upper molar of *Oldfieldthomasia*, but as these were not in place their evidence is not conclusive. The locality would repay more prolonged study than we were able to give it.

LAS VIOLETAS

On the estancia "Las Violetas," southeast of the small settlement of Malaspina, there is a long cliff with the Salamanca Formation at its base, followed by about 125 feet of fragmental and detrital, barren volcanic strata, then by a bentonite bed, up to 25 feet thick and often black at the base (probably "Banco Negro Superior"). Immediately above this clayey horizon begins a series with bentonite, sands of Río Chico character, and some white tuff. In the base of this last series, in hard sandstone, rare mammal bones occur. We found nothing more exactly determinable than a dasypod scute, and the locality has no present paleontological interest, but is mentioned as another possible site for Río Chico mammals, worthy of further investigation.

GAIMAN

Mammals were first found in the ancient sandstones near Gaiman by Roth. The rather complex history of this find and the misunderstandings that have arisen concerning it have already been reviewed in some detail (Simpson 1935a) and need not be repeated. Aside from Roth's specimens in La Plata and a few collected by us, there are several interesting specimens collected by A. F. Bordas, in the Museo Argentino, not yet described. The following fossils are known to me:

Polydolops rothi[1] Simpson
?*Polystylops minutus* (Roth) [*Monolophodon minutus*]
Isotemnus haugi (Roth) [*Lelfunia haugi*]
Notopithecidae indet.

Thus Casamayor groups are represented by distinct and apparently more primitive species, and although the very few specimens available do not warrant exact correlation, this is the character of the Río Chico fauna, with which lithology and stratigraphy are also in accordance, although not absolutely conclusive.

[1] A species known only from this locality. It is described in a paper in press at the Museo de La Plata.

RÉSUMÉ AND CONCLUSIONS

Of the various small faunules found in what is lithologically the Río Chico Formation, the following are most important:

1. a. The lower fossils from the Bajo de la Palangana.
   b. The lower fossils from the Cerro Redondo near Puerto Visser. These two small lots are from near the same level and the same general region.

Fig. 6. The Pan de Azúcar, near Gaiman.
The foreground is formed by the Río Chico sandstones, with barren ?Casamayor, Trelew, and Patagonian in the slope and cliff beyond.

2. The Cañadón Hondo sandstone fauna.
3. The upper sandstone fauna from the Bajo de la Palangana and vicinity.
4. The sandstone fauna of Gaiman.

(1) contains fossils not known from any other horizon and locality and not in themselves permitting positive correlation beyond the fact that they are of Tertiary aspect and are in agreement with the other evidence of a distinct and older mammalian faunal zone. The stratigraphic data, unusually clear in these cases, show that these are from the middle or lower part of the Río Chico. It cannot surely be estab-

lished whether they are significantly different in age from (2), but if so they are probably somewhat older.

(2), which may be considered the typical Río Chico fauna, is a fauna of early Tertiary, South American type. On present evidence, it appears to have no species in common with the Casamayor. It probably includes some Casamayor genera, but at least half and probably more of the genera are not known from any later horizon. The

Fig. 7. Close-up of the mammal-bearing sandstone of probable Río Chico age near Gaiman.

fauna is thus quite distinctive, as much so as is customarily true of two successive major Tertiary formations, and is of ancient type. Stratigraphically its zone underlies the Casamayor.

(3) resembles the Casamayor definitely more than does (2). In the latter there are no Casamayor species and few genera, while in (3) a few species and most of the genera are also found in the Casamayor. On this basis, it is highly probable that (3) is younger than (2), and stratigraphically, also, it is closer to the Casamayor, being from the highest sandstone perhaps immediately below, and certainly not over

six meters below, typical Casamayor sediments, with no evidence of a significant unconformity.

Both faunally and stratigraphically, (3) is closer to the Casamayor than it is to (2). On the other hand it is still distinct from the true or typical Casamayor and its horizon is lithologically part of the Río Chico. It is in effect a proto-Casamayor or a transitional Río Chico-Casamayor fauna. Whether this distinct faunal zone should be included nominally in Casamayor or Río Chico is an academic question, as long as its character and position are recognized. It seems to me somewhat better to include it provisionally in the Río Chico despite its close relation to the Casamayor. Certainly a complete gradation of faunas existed, and presumably intervening faunules now lacking will be found in these beds still so inadequately explored paleontologically. Somewhere in the sequence a division will have to be established between zones that differ no more than do (3) and the Lower Casamayor, and it is a point of practical importance that this division corresponds to the major change in sedimentation and lithology if, as now seems to be the case, the paleontological evidence also permits the recognition of such a boundary.

(4) is still too poorly known to warrant any worth-while deduction. As a hypothesis that seems to accord with present scanty data but requires further testing before elevation to the dignity of a theory, it may correspond approximately to (3).

There seem, then, to be at least two distinct pre-Casamayor faunal zones in the strata here under consideration. The Cañadón Hondo zone, with its distinctive and typical Río Chico fauna, is older, and the upper Palangana zone is younger, transitional to the Casamayor, to which it might conceivably be referred as a distinctive basal zone. The horizon of (1) in the list above may be approximately equivalent to but is probably somewhat older than the Cañadón Hondo zone, but fossils are still too few to determine this or, if it is older, to determine whether it can be characterized as a third separate and oldest zone.

As to the age of Río Chico, until 1931 no one seems to have differed from Ameghino's original opinion that these strata are Cretaceous. Ameghino considered them (correctly) as being related in a general way rather to his "Notostylopense" than to the still older Pehuenche (of Ameghino, not of more recent authors) and Chubutiano or "Areniscas Abigarradas," but he considered the "Notostylopense," Casamayor, as Cretaceous. When it was established beyond much question and generally accepted that the Casamayor is Tertiary, all students still

maintained that the beds now called Río Chico were Cretaceous. Except for lithologic resemblance, the positive evidence for this view, such as the supposed presence of dinosaurs and absence of mammals or the supposed angular unconformity, was all erroneous, but no positive evidence opposed this opinion.

Even after his discovery of mammals in these beds, Piatnitzky was inclined to continue considering them as Cretaceous, writing (1931, p. 16) that "antes de estudiar estos fósiles, sería aventurado llegar a una conclusión con respecto a la edad de las areniscas. De todos modos, su posición estratigráfica muy baja y la semejanza entre su composición litológica y la del Pehuenche propiamente dicho,[1] talvez indiquen su pertencia al Cretáceo, a la cual época, por consiguiente, deberían referirse los huesos de mamíferos encontrados en las mismas areniscas." Feruglio considered the question open to further discussion, without himself expressing an opinion, saying of the mammal finds of Piatnitzky and of Brandmayr (Feruglio 1931, p. 22) that "estos hallazgos, junto a las consideraciones que he expuesto arriba,[2] ponen en discusión la edad (terciaria o bien cretácea) del Pehuenche,[3] cuya aclaración sólo puede esperarse de un estudio paleontológico."

I have already (1932B, pp. 7–8; 1933, pp. 11–12) expressed the opinion that the Río Chico Formation is definitely Tertiary, and this opinion now seems to me to be proved correct beyond any doubt. The only remaining evidence for Cretaceous age is that mentioned by Piatnitzky, the low position of the Río Chico and its lithologic character. Since the Casamayor is certainly not as old as the base of the Paleocene, a formation, or even a series of several thick formations, below it need not necessarily or probably be Cretaceous merely because of this lower position. In North America there are several thousand feet of Tertiary sediments below the oldest formation that is at all likely to be equivalent in age to the Casamayor. As to lithology, its evidence carries no weight if confronted by any positive opposing data. That the change in type of sediments corresponds to the Cretaceous-Tertiary boundary was a justified hypothesis as long as no other basis for separation existed, but immediately falls to the ground now that there is better evidence for drawing the line. The type of sedimentation continued the same for

[1] I.e., the beds above the Salamanca in which mammals have not yet been found. Their age and correlation is still in doubt. Much of them probably belongs to the Río Chico, but the presence of post-Salamanca Cretaceous is entirely possible.

[2] The absence of any authenticated discovery of dinosaurs contemporaneous with these mammals.

[3] I.e., Río Chico.

some time into the Tertiary, or the earliest Tertiary beds were formed by material remanié from the Upper Cretaceous strata.[1]

The Río Chico fauna includes many mammals, mostly ungulates in a broad sense and already distinctly differentiated into the Tertiary orders, or even families, and does not include dinosaurs. Such a fauna has never been found in any other part of the world except in the Tertiary. It is not inconceivable that such a fauna might exist somewhere in the Cretaceous, but the burden of proof is on the opinion that it might be Cretaceous.

From another approach, it is a necessary assumption that the original stocks of the South American mammals were connected with those of some other part of the world, and it is highly probable that the connection was in the latest Cretaceous or earliest Paleocene. The Río Chico mammals, primitive as they are, are considerably removed from and differentiated beyond possible connection with the earliest known and most nearly similar mammals of any other part of the world, and hence are probably considerably post-Cretaceous.

Another and less theoretical line of evidence is afforded by the few Río Chico mammals that do compare at all closely with those known from other continents. *Patene*, very primitive as a borhyaenid, is yet considerably more advanced in this direction than the latest Cretaceous marsupials of North America. *Ernestokokenia* closely resembles Middle Paleocene to Lower Eocene condylarths of North America (and Europe), and I think it is closely related to them both in blood and in degree of evolutionary advance. The Río Chico henricosborniids resemble, and are about as advanced as, the Upper Paleocene and Lower Eocene arctostylopids of Asia and North America. If *Carodnia* is related to the uintatheres, which is possible but still hypothetical, its closest allies are from the Upper Paleocene of Asia and North America.

A fourth sort of faunal evidence concerns the relation of the Río Chico fauna to later South American faunas. The age of the Casamayor is not known with any exactness. It is almost surely Eocene, and long consideration of all the evidence convinces me that it cannot be older than Lower Eocene and may be Middle Eocene or even, but with much less probability, Upper Eocene. Supposing it to be as old as any evidence warrants considering it, Lower Eocene, then the Río Chico fauna (*Kibenikhoria* zone) could hardly be judged as older than Middle

[1] Furthermore the strata with which Piatnitzky was making special lithologic comparison are not themselves definitely known to be of Cretaceous age. It should also be mentioned that the lithologic change is not so definitely associated with the beginning of a period of strong vulcanism as might be supposed, for volcanic rocks of many types are very characteristic of the undoubted Cretaceous also.

Paleocene, from its general evolutionary level and degree of resemblance to the Casamayor fauna.

The conclusion on these considerations is that the Río Chico fauna is certainly Tertiary and that its age is with much probability somewhere in or between the Middle Paleocene and the Lower Eocene. Upper Paleocene seems most likely, but is a more exact correlation than the evidence warrants.

Since the known Río Chico fauna is probably not of earliest Tertiary age and since its notoungulates suggest previous differentiation which almost surely took place in South America, it is to be expected that still older Tertiary faunas occurred there and it is to be hoped that they are preserved and will yet be discovered. If a real fauna were found in the *Carodnia* zone, it might possibly prove to be older than that of *Kibenikhoria* and would in part fill in this remaining gap. In the meantime, the fossils here described are the oldest known South American mammals.

To facilitate further discussion of and reference to these problems, I suggest that the possibly distinct faunules within the Río Chico be tentatively designated as follows:

Formation	Zones and Faunas
	Ernestokokenia chaishoer (3 of list given above)
Río Chico	*Kibenikhoria* (2 of list given above)
	Carodnia (1 of list given above)

ADDENDUM TO NOVITATES NO. 793

Since the descriptions of the Río Chico fossils were published I have received from Doctor Cabrera casts of the two specimens found by Ing. Brandmayr in the *Carodnia* zone of the Bajo de la Palangana, as mentioned on a previous page. Doctor Cabrera will describe these, but they are mentioned here to complete reference to all that is yet known of the Río Chico formation and fauna. One is identical in structure with the type of *Carodnia feruglioi*, and I suspect it of being the right M_3 of the same individual. The other is a premolar unlike any specimen otherwise known from the formation and of uncertain affinities.

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